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ABSTRACT

This paper reports on part of a cross-national study of science classroom environments in Taiwan and Australia. It focuses on teachers' beliefs about science and science teaching and the effects these beliefs have on the learning environment in the science classroom. Better understanding of this relationship between teacher beliefs and learning environment can lead to the identification of the barriers to the introduction of constructivist teaching approaches in school science. Descriptions of the Classroom Learning Environment Survey and the Beliefs about Science and School Science Questionnaire are provided. Statistical analyses of questionnaire data for each country are also provided and contain internal consistency reliability, discriminant validity, mean scores, and standard deviations. Recommendations for further research include using existing questionnaires as interview/observation frameworks and for future research to be guided by a set of interpretive research questions. (DDR)

Development of a Questionnaire for Assessing Teachers' Beliefs About Science and Science Teaching in Taiwan and Australia

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Introduction

This paper reports part of a cross-national study of science classroom environments in Taiwan and Australia. It focuses on teachers' beliefs about science and science teaching, and the effects these have on the learning environment of the science classroom. By understanding more about this relationship, especially from a cross-national perspective, it is hoped that barriers to the introduction of constructivist teaching approaches in school science can be identified and strategies proposed for enabling teachers, curriculum developers, and policy-makers to overcome them.

Survey instruments for assessing teacher beliefs and classroom environment have been developed and validated for use in Taiwan and Australia. The *Beliefs About Science and School Science Questionnaire (BASSSQ)* was designed specially for this cross-national study to enable us to assess teachers' beliefs about the nature of science and school science. The *Constructivist Learning Environment Survey (CLES)*, which was designed previously to assess students' perceptions of the constructivist nature of their classroom learning environments, was adapted for use in this study.

The cross-national nature of the study required that both questionnaires be translated into Chinese. A process of 'back translation' was employed to ensure that Chinese-speaking and English-speaking teachers and students made sense in similar ways of the questionnaire items. Further refinements were made based on interviews with teachers and students about their comprehension and interpretation of the items.

The CLES was administered to students in 50 junior high school science classes in Taiwan and 27 junior high school science classes in Australia. The teachers of each of the classes responded to the BASSSQ. In this paper, we present for each country the following statistical analyses of questionnaire data: (1) internal consistency reliability and discriminant validity; and (2) mean scores and standard deviations. Qualitative analyses of teachers' responses to the BASSSQ have been reported elsewhere (Aldridge, Taylor & Chen, 1997).

Teacher Beliefs

The study of classroom learning environments has been of international interest over the past twenty years (Fraser, 1994). Recently, attention has focussed on the learning environments of classrooms in which constructivist curriculum reforms are being introduced (Taylor, Fraser & Fisher, in press). The referent of constructivism carries with it the promise of major changes in the ways teachers and students view the nature of knowledge. Constructivist classrooms provide students with an enhanced sense of agency as learners who co-construct (rather than receive) their scientific knowledge (Taylor, in press).

However, research on teacher thinking suggests that teachers' extant beliefs are likely to be a major barrier to the uptake of constructivist curriculum reforms. For some time, it has been realised that teachers beliefs play an important role in shaping their classroom actions (Clark & Peterson, 1986). Research has shown that difficulties concerning the implementation of curriculum innovations in the classroom often are related to the resistant nature of teachers' beliefs (Munby, 1982; Nespor, 1987; Nisbett and Ross, 1980). Teachers tend to modify new science curricula to make them more compatible with their extant beliefs about the centralist nature of their classroom roles (Duschl & Wright, 1989; Olson, 1981).

Recent studies have found that teachers' beliefs about the nature of science can affect the way in which science is portrayed in the classroom (Brickhouse, 1991). The images that teachers hold of the nature of science have been associated with the dominant the nature of processes involved in generating scientific knowledge. The Epistemic Status scale assesses teachers' views of the certainty of scientific knowledge. Table 1 shows the two-part structure of the BASSSQ, including the matching pairs of scales and sample items. A copy of the original 41-item BASSSQ is appended to this paper.

Teachers' responses to the items are recorded on a five-point Likert-type frequency response scale. In scoring, each item response is allocated 1, 2, 3, 4, or 5 points for each of the response categories *Almost Never, Seldom, Sometimes, Often* and *Almost Always*, respectively. Items aligned with an objectivist view are scored in reverse and, during statistical analysis, are adjusted accordingly. A scale mean score is calculated by dividing the total scale score by the number of respondents and the number of scale items. Thus, the scale mean scores range between 1 (Almost Never) and 5 (Almost Always). A higher score indicates more postmodern view of the nature of (school) science and a lower score represents more objectivist view.

Table 1
Structure of the BASSSQ

Scale	Description	Sample Item
Part A: Teacher's View of the Nature of Science		
Process of Scientific Inquiry	The nature of the inquiry process used by scientists to generate scientific knowledge	1. Scientific observations depend on what scientists set out to find. 8. Scientific inquiry starts with observations of nature.
Status of Scientific Knowledge	The status or certainty of scientific knowledge, ranging from secure to contingent.	11. Scientific knowledge gives a true account of the natural world. 12. Scientific knowledge is tentative.
Part B: Teacher's View of the Nature of School Science		
Process of School Science Inquiry	How scientific inquiry should be represented in school science	21. In science classes, investigations should enable students to explore their own ideas. 28. In science classes, students should apply the scientific method.
Status of School Science Knowledge	How the status or certainty of scientific knowlede should be represented in school science.	32. In school science, students should be critical of accepted theories. 41. In school science, students should be taught that scientific knowledge is objective and therefore free of human values .

NB Underlined items reperesent an objectivst view and are scored in reverse

The CLES

The Constructivist Learning Environment Survey (CLES) was designed to assess students' perceptions of the constructivist nature of their classroom learning environments. A combination of small-scale qualitative studies and large-scale quantitative studies has provided substantial evidence that the CLES can be used to monitor the development of constructivist learning environments in school science in Western cultures (Taylor, Fraser & Fisher, in press).

The CLES contains 30 items altogether, with six items arranged in each of five scales. Each scale of the CLES was designed to obtain measures of students' perceptions of the frequency of occurrence of five key dimensions of a critical constructivist learning environment. Table 2 shows the structure and sample items of the CLES. The response

Thus, the Taiwanese and Australian data were drawn from samples of convenience rather than from representative samples of junior science classroom environments in either country. Because the study was designed to enable the Taiwanese and Australian researchers to learn collaboratively about the teaching and learning of science within their respective countries, rather than to make comparisons between countries, this sampling method was appropriate.

Reliability and Validity

Steps were taken to optimise the internal consistency and independence of the scales of the newly-developed BASSSQ. During the development process, a series of interviews was conducted with science teachers to ascertain the clarity and comprehensibility of the items. As a result, a number of the original 50+ items were modified or rejected. This process and the results for the Australian sample are reported elsewhere (Aldridge, Taylor, Chen, 1997). The revised 41-item questionnaire which emerged from these early and intensive trials was administered to the sample described above. During subsequent statistical analyses, further unreliable BASSSQ items were excluded in an endeavour to improve scale internal consistencies. This resulted in a refined 33-item version of the revised BASSSQ whose psychometric properties are displayed in Tables 3 and 4 below. These tables present separately for the Australian and Taiwanese samples the indices for internal consistency *(Cronbach's alpha reliability)* and discriminant validity *(mean correlation with other scales)* for each of the scales of the BASSSQ and CLES.

Internal Consistency

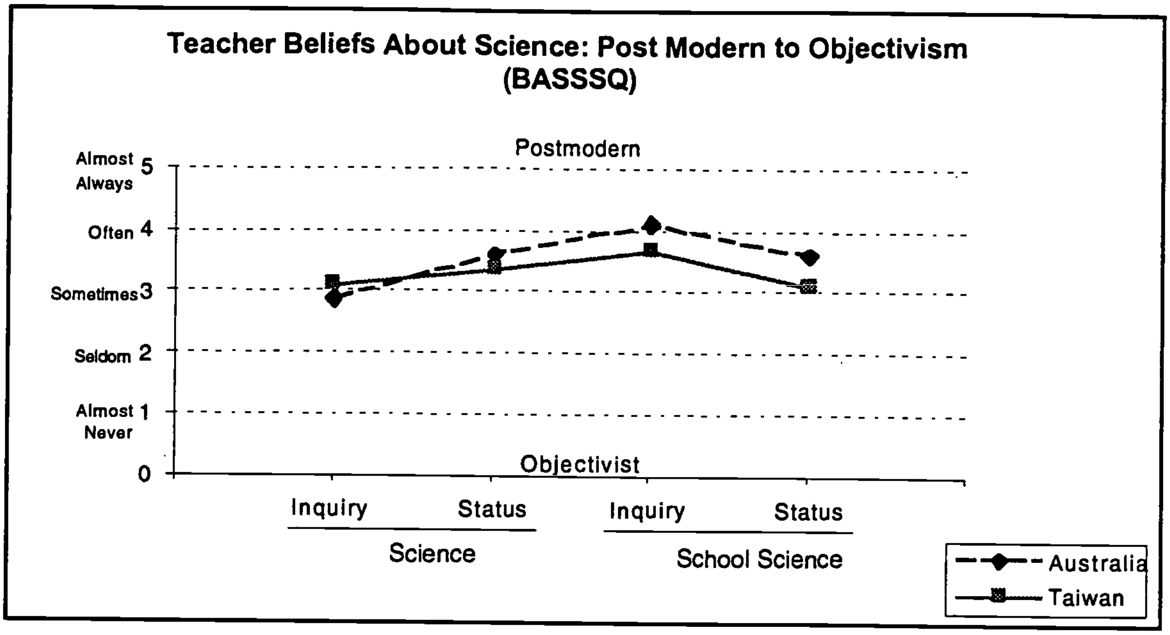
The internal consistency of the scales of the BASSSQ range from somewhat unsatisfactory *(0.46/0.51 - Process of Scientific Inquiry)* to very satisfactory *(0.91/0.81 - Process of School Science Inquiry)*. The results are similar for both countries.

The internal consistency of the CLES scales range from satisfactory *(0.71/0.78 - Personal Relevance)* to highly satisfactory *(0.92/0.93 - Critical Voice)*. The results are similar for both countries, except for the Uncertainty scale which has a relatively smaller degree of internal consistency for the Australian sample.

Table 3
BASSSQ: Internal Consistency and Discriminant Validity

Scale	No. of Items	Cronbach Alpha		Mean Correlation With Other Scales	
		Australia (N=27)	Taiwan (N=50)	Australia (N=27)	Taiwan (N=50)
Process of Scientific Inquiry	8	0.51	0.46	0.38	0.30
Status of Scientific Knowledge	8	0.74	0.68	0.38	0.23
Process of School Science Inquiry	9	0.81	0.91	0.44	0.38
Status of School Science Knowledge	8	0.78	0.89	0.49	0.28

Figure 1



Differences

The most noteable difference between the professed beliefs of Taiwanese and Australian science teachers concerns their views on the nature of school science. Australian teachers seem to be somewhat more postmodern with their beliefs about how scientific inquiry should be experienced by students in class. It seems that the Australian teachers believe that students should be engaged often in collaborative and open-ended investigation, whereas Taiwanese teachers believe that this should occur somewhat less frequently. Although the same difference is apparent in relation to Australian and Taiwanese teachers' views on the status of school science knowledge, there seems to be relatively less concern amongst the Taiwanese teachers for representing scientific knowledge as evolving, tentative and contingent.

Students' Perceptions of the Classroom Environment

The overall pattern of results (see Table 6 and Fig 2) suggests that, from students' points of view, constructivist teaching practices occur infrequently (i.e., less than often) in both Australian and Taiwanese junior science classrooms. In particular, both Australian and Taiwanese students perceive that what they learn is relevant only sometimes to the world outside of school (i.e, Personal Relevance).

Table 6
Students' Perceptions of the Constructivist Nature of the Classroom Environment (CLES)

Scale	No. of Items	Scale Mean Score*		Standard Deviation	
		Australia (N= 519)	Taiwan (N=1879)	Australia (N= 519)	Taiwan (N=1879)
Personal Relevance	6	3.1	3.3	0.7	0.8
Uncertainty	6	3.3	3.7	0.8	0.8
Student Negotiation	6	3.3	2.7	0.9	0.8
Shared Control	6	2.1	2.5	0.9	1.0
Critical Voice	6	3.4	3.1	0.9	0.9

*NB. Maximum possible scale score = 5; minimum possible scale score = 1.

continuum. However, Australian teachers seem to have a somewhat more postmodern view of how students should experience science in their classrooms.

From the general perspective of the students, the learning environment of science classrooms is not often constructivist in nature. The largest single difference concerns the relatively infrequent opportunity for Taiwanese students to engage in reflective discussions with other students during class. On the other hand, Taiwanese students perceive slightly more frequent opportunities to experience the uncertainty of scientific knowledge and share with teachers control of their learning.

Next steps in the research include penetrating the statistical (smoke?) screen and observing life in actual science classrooms. Usually, mean scores mask a range of individual differences that standard deviations, at best, can only hint at. An analysis of individual CLES responses is likely to indicate one or more relatively highly constructivist classroom environments in both Taiwanese and Australian schools. It would be interesting, therefore, to conduct participant-observation studies of these classroom environments in order to identify and compare constructivist teaching practices and the corresponding nature of teachers' epistemologies.

In Taiwan and Australia, classroom-based participant-observation studies could make use of the already-completed questionnaires as interview/observation frameworks and be guided by the following interpretive research questions.

1 What specific teaching practices give rise to opportunities for students to enjoy an enhanced sense of agency as learners?

2. What beliefs about knowledge and the nature of science (on the postmodern-objectivist continuum) are held by these teachers, and which beliefs do they enact in their science classrooms?

3. What strategies do these teachers employ to overcome successfully the restraints of external curriculum and assessment policies?

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Appendix 1
BASSSQ

Your Views About What Occurs in Science

Please indicate how often, in your opinion, each practice **occurs in science.**

Process of Scientific Inquiry	Almost Never	Seldom	Sometimes	Often	Almost Always
1.* Scientific observations depend on what scientists set out to find.	1	2	3	4	5
2. Scientific inquiry involves challenging other scientists' ideas.	1	2	3	4	5
3. Scientific observations are affected by scientists' values and beliefs.	1	2	3	4	5
4.* Scientific inquiry involves thinking critically about one's existing knowledge.	1	2	3	4	5
5. Intuition plays a role in scientific inquiry.	1	2	3	4	5
6. When making observations, scientists eliminate their beliefs and values.	1	2	3	4	5
7. Scientific observations are guided by theories.	1	2	3	4	5
8. Scientific inquiry starts with observations of nature.	1	2	3	4	5
9. Scientific investigation follows the scientific method.	1	2	3	4	5
10. Scientific ideas come from both scientific and non-scientific sources.	1	2	3	4	5

Certainty of Scientific Knowledge	Almost Never	Seldom	Sometimes	Often	Almost Always
11. Scientific knowledge gives a true account of the natural world.	1	2	3	4	5
12. Scientific knowledge is tentative.	1	2	3	4	5
13. Scientific knowledge is relative to the social context in which it is generated.	1	2	3	4	5
14.* Scientific knowledge can be proven.	1	2	3	4	5
15. The evaluation of scientific knowledge varies with changes in situations.	1	2	3	4	5
16. The accuracy of current scientific knowledge is beyond question.	1	2	3	4	5
17.* Currently accepted scientific knowledge will be modified in the future.	1	2	3	4	5
18. Scientific knowledge is influenced by cultural and social attitudes.	1	2	3	4	5
19. Scientific knowledge is free of human perspectives.	1	2	3	4	5
20. Scientific knowledge is influenced by myths.	1	2	3	4	5

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Appendix 2
CLES

Learning about the world	Almost Always	Often	Sometimes	Seldom	Almost Never
In this class . . .					
1 I learn about the world outside of school.	5	4	3	2	1
2 My new learning starts with problems about the world outside of school.	5	4	3	2	1
3 I learn how science can be part of my out-of-school life.	5	4	3	2	1
In this class . . .					
4 I get a better understanding of the world outside of school.	5	4	3	2	1
5 I learn interesting things about the world outside of school.	5	4	3	2	1
6 What I learn has <u>nothing</u> to do with my out-of-school life.	5	4	3	2	1

Learning about science	Almost Always	Often	Sometimes	Seldom	Almost Never
In this class . . .					
7 I learn that science <u>cannot</u> provide perfect answers to problems.	5	4	3	2	1
8 I learn that science has changed over time.	5	4	3	2	1
9 I learn that science is influenced by people's values and opinions.	5	4	3	2	1
In this class . . .					
10 I learn about the different sciences used by people in other cultures.	5	4	3	2	1
11 I learn that modern science is different from the science of long ago.	5	4	3	2	1
12 I learn that science is about <u>inventing</u> theories.	5	4	3	2	1

Learning to speak out	Almost Always	Often	Sometimes	Seldom	Almost Never
In this class . . .					
13 It's OK for me to ask the teacher "why do I have to learn this?"	5	4	3	2	1
14 It's OK for me to question the way I'm being taught.	5	4	3	2	1
15 It's OK for me to complain about activities that are confusing.	5	4	3	2	1

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